J. O. Westwood Esq
with the Author's compts

ON THE

SCOPE AND TENDENCY

OF

BOTANICAL STUDY;

AN INAUGURAL ADDRESS

DELIVERED BEFORE THE

Liverpool Royal Infirmary School of Medicine,

MAY 3, 1858,

BY

BY CUTHBERT COLLINGWOOD, M.A. & B.M., OXON.,
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FELLOW OF THE MEDICAL SOCIETY OF LONDON,
OF THE ROYAL MEDICAL SOCIETY OF EDINBURGH,
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LECTURER ON BOTANY AT THE ABOVE INSTITUTION;
ETC.

LONDON:
LONGMAN, BROWN, GREEN, LONGMANS, AND ROBERTS.
LIVERPOOL: E. HOWELL, 6, CHURCH STREET.

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SCOPE AND TENDENCY OF BOTANICAL STUDY.

An Inaugural Address delivered before the Liverpool Royal Infirmary School of Medicine, May 3rd, 1858.

GENTLEMEN,

THE Lecturer on Botany in our Schools of Medicine labours under a disadvantage which some may wish to ignore, but which I think should be fearlessly stated, as the best means to insure its removal, or at least its diminution. It is, that Botany, as a general rule, is *not* a popular study with medical students. The broad fact is one which no one will dispute, and for which, I am ready to admit, there exist some apparently reasonable grounds; but while I consider it right that these should be stated at the outset, I shall also adduce certain considerations which appeal to the good sense of the student, and will place the matter before him in such a light, that I trust he will see reason to suspend his judgment upon the utility of the study of Botany, and not follow in the train of the many, who, without giving the subject an independent thought, allow a prejudice to take possession of their minds, and to deprive them of the advantages derivable from the study in question.

The curriculum through which it is necessary that the student of medicine should pass before he can be considered as possessing a knowledge of disease and a due acquaintance with the art of healing, embraces numerous subjects which either directly or collaterally bear upon these two practical ends of his profession. Anatomy, Physiology, Pathology, Chemistry,

and Botany are among those subjects, through an acquaintance with which he arrives at that facility in rapid and accurate diagnosis—that aptitude for duly balancing the importance of subtle influences and suggestive changes which assists the formation of a correct prognosis—that quick perception of the indications afforded for appropriate remedies—and that familiar acquaintance with the nature of those remedies, which are the essential elements of success in medical practice. But each of these subjects involves a certain amount of mental labour, and the whole, if properly attended to, presents no inconsiderable task. The student, therefore, not fully cognisant of the tendency and result of these studies, usually endeavours to relieve his mind as much as possible from either of the subjects which he conceives to have least practical bearing upon his profession—and he seldom fails to include *Botany* in that category.

Another reason of the disfavour with which this science is regarded is to be found in the complexity of its glossology. The cursory and unscientific mind is too ready to regard Botany as a mere useless enumeration of hard names; but nothing can be more unjust than this prejudice. It is true that Botany, like other natural sciences, is overlaid with a technology which has been increased to a somewhat cumbrous extent by the carelessness and vanity of authors. While, however, we must admit that a revisal of terms used in the science would be very acceptable, were it possible to be carried out, we must bear in mind that by far the greater number of these technical expressions are both necessary and useful. Organisms which are so various and so complex as plants necessitate a nomenclature which shall be sufficiently exact to discriminate safely and easily between not only generic and specific differences, but also between the more nice distinctions of cultivated and hybridal varieties to which they are so peculiarly susceptible. The value of a nomenclature which accomplishes this should be at once recognised, and although it may cost an effort at first to master the principal terms, the student may feel assured that his labour is well bestowed, and will bring him ample return in the facility which it affords for the comprehension of the science, as well as in the mental training which it involves.

The ingenuity and completeness of botanical terminology has been referred to as a pattern for imitation, and as illustrating the precision with which technical terms may be framed to suit the endless varieties of form and structure with which the botanist has to deal, and to picture to the mental eye a vivid and accurate image of an absent plant. By the commencing student, however, it is liable to be misunderstood, its value misinterpreted, and its difficulty over-rated; and although it is open to the objection just referred to, it would be folly to under-value so useful and important an auxiliary.

It is too much the fashion to look upon Botany as an amusing, but barren accomplishment, to be pursued when nothing more serious claims the attention. But while on the one hand it must not be considered as a mere enumeration of hard names, so also it does not consist in a mere collection of dried plants. The day when the greatest collector was regarded as the greatest naturalist is happily past. True it is that collections have their use, and an important one it is when they are properly applied; but the *mere* collector cannot now pass muster as a botanist. The *real* botanist has a wider and more extended aim; for though it is possible that more serious subjects may in their proper season claim attention, it must nevertheless not be forgotten how comprehensive a science is his—how intimately it bears upon the phænomena of life—how universal are the objects whose study it embraces—how important a *rôle* they perform in the economy of nature—how vital a necessity they are to man, no less than to the lowest animal.

But of those studies which I have alluded to as constituting medical education, none can be dispensed with without involving a defect in the groundwork, and a corresponding weakness in the superstructure. The very fact that a course of Botany is included in the requirements of the examining Boards should be sufficient to convince the thinking student that there may be a value discoverable in such a course and in the instruction which it either conveys or induces, which he, on the very threshold of his studies, is scarcely in a position to appreciate, and which he should be ready to accept on trust

from those whom superior age and experience constitute the natural and proper, as well as official, guides of his course of study.

The advantages derived by the medical student from the study of Botany are of two kinds—*immediate* and *implied.* In order to set the former in their proper light, we will glance at the true scientific position occupied by Botany in the medical curriculum. Disease, and its relief or cure, are the two prominent points to which, through all his studies, the attention of the student is mainly directed. Before he can duly understand morbid action or pathological relations, he must have a clear perception of healthy action or physiological relations; and before he can comprehend the sufficient and normal performance of functions, he must possess a minute and accurate acquaintance with structure. Anatomy, therefore, is the groundwork of that first great practical part of medicine which consists in the perception of the nature of disturbed function, and the knowledge of the true cause and seat of diseased action. But he would be but a useless practitioner who, though ever so well skilled in diagnosis, should be unacquainted with the means of alleviating suffering by the application of remedies, or of curing disease by the administration of drugs. So that a knowledge of therapeutic agents is an essential qualification for the duly educated medical man. Now these therapeutic agents are, for the most part, of two distinct kinds, derived from two kingdoms of Nature—the inorganic, or mineral, and that subdivision of the organic kingdom which includes vegetables. A due acquaintance with mineral remedies involves the study of Chemistry—a study which is never afforded grudgingly, but, on the contrary, is always regarded as a necessary, useful, and practical branch of medical learning. Of therapeutic agents, however, while about one-fourth only are derived from the inorganic world, the remaining three-fourths are obtained from members of the vegetable kingdom; and no one will be so hardy as to affirm that they include the least important remedies. On this ground, therefore, it does not appear why the science which especially treats of this large and valuable class of materia medica should be regarded with contempt.

It is quite true that Chemistry has important physiological bearings which are more apparent or more practical than those of scientific Botany, as well as a general application to both classes of the materia medica, inasmuch as the organic branch of it, which has received such extensive additions of late years, gives us some information, and I trust will give yet more, relative as well to the *modus operandi* of medicines upon the system, as to the combination of mineral and vegetable substances for the formation of new and more subtle compounds. But the fact that Chemistry has a wider application does not appear to afford any reason why that science should be neglected by the student of medicine, which, in the words of Professor Lindley, "teaches the physician how to discover in every region the medicines that are best adapted for the maladies prevalent in it, and which furnishes him with a certain clue to the knowledge of the tribes in which particular properties are, or are not to be found."

It is only by means of a scientific acquaintance with Botany that our knowledge of medicinal plants can be increased and perfected. None but those whose intimate acquaintance with vegetable physiology enables them to trace out affinities and to understand the true position of newly discovered plants in the natural scale, can be expected to enlarge the usefulness of the vegetable world by bringing to light health-bearing treasures which have to this time escaped observation. It has been considered probable that the vast number of plants with which we are at present acquainted comprises little more than one-half of those which really exist, and we can scarcely imagine that this unknown moiety does not contain plants whose properties are little, if any, inferior to those with which we are already acquainted. It is possible that among them may be found remedies of which we at present little dream; and while such extended acquaintance with the members of the vegetable creation cannot fail, by bringing into prominence new affinities and analogies, gradually to perfect the natural system of classification, so, on the other hand, this very approximation to a philosophical scheme of Botany will tend to diminish the uncertainties of medical practice by enlarging our knowledge

of specific remedies, and thus afford data which may assist in rendering medicine a more exact science. The sources of many valuable and well-known remedies which have long been used and appreciated, are still unknown to us, and their products reach us only in a commercial and crude state. It is the business of the scientific botanist to clear up these doubts, and thus assist in paving the way from empiricism to rational principles.

But besides these evident bearings of the science of Botany upon the pursuits of the medical practitioner, there are others which I have referred to under the term *implied* advantages, which, although they are less evident on a cursory inspection, exert no inconsiderable influence upon the professional character. It would indeed be difficult to define the exact amount of influence exercised by each one of the medical sciences upon the great practical ends in question—for each assists the other, and in the general and complete scheme the educational deficiencies of one are supplied by corresponding excellencies in another. One, specially descriptive, appeals to the memory, and is useful in exercising that important function; another, more particularly logical, addresses itself to the judgment; a third to some other faculty of the mind: so that all in turn are called into action, and none are permitted to lie dormant.

It cannot be doubted that the study of Nature has considerable effect in expanding the mind and sharpening the intellectual powers. The infinite variety of organs and of forms—the wonderful and beautiful adaptations which everywhere arrest the attention in the study of living organisms—the extraordinary exhibitions of contrivance and design which without fail unfold themselves before the careful and candid inquirer, tend materially to strengthen the mental tone and to elevate the general character; and for this reason it is well calculated to be made a branch of general liberal education. The minute attention and the accurate examination and discrimination which plants demand is an excellent training for the mind, and singularly favourable to habits of observation. Such habits of observation are peculiarly useful and valuable to the medical practitioner, and assist him greatly in the formation of a correct diagnosis. For as the botanist omits no organ, however incon-

spicuous, no mark, however slight, in his examination of a plant, with a view to trace its affinities, so the physician at the bedside passes by no symptom, however obscure, no hint, however vague, well knowing that a just opinion may result from a combination of circumstances minute and unimportant in themselves, or even from one little fact, for the elucidation of which a keen and subtle search is necessary. Thus the training which the botanist gives himself is not without its direct bearing upon his professional capacity, as well as on his perception of obscured truth in any other inquiry to which he may direct the powers of his mind.

Again, the varied studies which medical men require, in order to fit them for the practice of their profession, tend to render them, as a class, the best-informed men in society—and it is right that it should be so; and while asserting this proud position, it would be pity indeed if they should be found deficient in a branch of scientific inquiry bearing so directly upon their profession. The class of medical practitioners is that class to whom, *ex officio* as it were, we are indebted for our knowledge of anatomy and physiology, and of biological science—they are the chief depositaries of the arcana of natural science in general, and of the phenomena of life in the vegetable, no less than in the animal kingdom. A few narrow-minded individuals may grudge them this wide range of knowledge, and may wish to limit them to the strict and exclusive study of professional subjects; but such illiberal and short-sighted views are, I trust, at the present time fast dying out. I may perhaps be pardoned if, by way of carrying authoritative weight upon this subject, I here use the words of the late eminent and lamented Professor Edward Forbes, who, fifteen years ago, on an occasion similar to the present, observed, "A time was, when an acquaintance with the purely practical parts of the profession was all too many practitioners thought it necessary to acquire. This degrading idea was favoured by the non-professional public, and to gain a prominent position in literature or science was too often to close the gates of professional success. But that time is either gone by, or is fast waning away. That profession, the investigation of which involves

some of the deepest problems in human philosophy, must become more and more philosophical every day. Sound education in literature and scientific instruction in his profession are fast elevating the character of the medical student; and in the end, an unscientific practitioner will become as rare as a medical sceptic."*

But before quitting this part of my subject, which relates to the inducements which this science holds out to the student of medicine, I will allude to one which is too generally overlooked. In every active profession it is advisable to have some pursuit which shall act as a relief, or safety valve, if I may so term it, to the pressure of every-day business. A mind which has been harassed by professional routine reverts gladly, in its moments of leisure, however scanty, to something which is at once congenial and interesting—something which may be pursued for its own sake—some recreation which, although itself requiring thought and attention, is yet a change, and turns the mental activity into another channel. The truly philosophic mind is never idle, and although immediately professional calls do not challenge him, he is not content to pass these intervals in sloth and inactivity, but will find it agreeable—nay, *necessary*—to have something to which to turn in these leisure moments. And let no one imagine that such leisure moments have no existence—only he who has endeavoured to reckon them, and to turn them to account, is able to judge how numerous and how valuable they are. Minutes make hours, and hours days, and days months; and if the first are neglected, the last are lost; and the student who conscientiously garners his spare moments, and exchanges them for scientific information, will find himself possessed of a rich harvest of knowledge, which will be a never-failing source of enjoyment in the pursuit, as well as a treasure accumulating for the future. Many have lived a second life by the discriminating use of intervals of leisure, and have surprised the world by their acquaintance with subjects for the attainment of which their active business life has appeared to leave no space; but it is by a jealous and methodical employment of such intervals that

* Prof. E. Forbes' Inaugural Lecture at King's College, May, 1843.

the wonder has been effected. Scientific eminence is NOT incompatible with the pursuit of an active profession: this axiom is proved by the numerous examples around us in our own day, of men who have reached the highest pinnacle of professional eminence, and at the same time have acquired a scientific reputation second to none. Such examples must occur to every one, drawn from all professions, and embracing every department of literature and science.

Again, there is a contingency to which medical men are liable, and which should be early provided against. A time may come—it may be soon, it may be late—when circumstances may render it necessary to abandon the practice of their profession. Fortune may smile, or may frown, illness may incapacitate, or other circumstances may combine to prevent a further pursuit of its active duties. The incapacitated by sickness or accident are thrown back upon their own internal resources—the retired practitioner seeks rest from his labours, and promises himself ease and enjoyment—how vainly! if nothing but strictly professional duties have occupied his life. He is restless, unhappy, disappointed, soured by ennui, and instances will not be wanting to the minds of all, in which he has rushed back into the tide of an active professional career, as the only means of escape from the burden of *himself*.

But there is an internal source of gratification and pleasure arising from the study of Botany in common with the other departments of Natural History—an intellectual enjoyment which springs from a perception of beauties which unfold themselves at every step to the diligent inquirer in the field of Nature, which especially adapts itself to all these cases, and renders it peculiarly fitted to be followed out as an extra-professional pursuit. No one can arrive at a well-grounded knowledge of those wonderful modifications of organs to meet an infinite variety of conditions—at the exquisite balance which is maintained either in the vegetable world itself, or in its relations to the inorganic world on the one hand, and to the animal creation on the other,—no one can contemplate their vital actions, their physiological conditions, without feeling a deep sentiment of wonder, and a degree of fascination in the

study of them. Even a cursory view is provocative of admiration, as their beautiful flowers appeal to our senses of sight and smell, and tall and stately trees afford us an umbrageous shelter, making us long to know more concerning the members of that middle kingdom of Nature, of what elements they are composed, in what manner they are combined or aggregated, what are the conditions of their well-being, and what is the nature of the forces which set the dormant seed in action to become the living plant, and which give the decaying plant the power of reproducing its like, before it finally returns to the inorganic elements from which it built itself up. The very fact of having stepped within the threshold of Nature's temple gives a man self-respect and a just feeling of superiority which elevates him above his fellows.

There are advantages, too, of a physical nature, which, as they illustrate the adaptability of this study to the cases in question should not be altogether passed over in silence. The pursuit of the science, while it affords a pleasing recreation from the stern duties of actual life, at the same time offers an inducement to a healthful out-door occupation, so conducive to the *mens sana in corpore sano*. The objects which it embraces are to be found everywhere under the canopy of the sky, unless they have been thrust aside or trampled under foot by the self-imposed necessities of men; and thus while they attract the inquirer to the woods and fields, their native haunts, for purposes of observation, they at the same time afford constant and unfailing food for contemplation; and while, on the one hand, they prevent the mind from falling into vacant inactivity, and thus assist in keeping up a healthy tone, on the other hand, they distract the attention from pressing cares, which otherwise sometimes unnecessarily intrude themselves, even in what should be moments of relaxation; so that in either case physical and mental health mutually react and fortify one another.

Thus far I have confined myself to the strictly medical aspects of Botany, and endeavoured to show that these alone are sufficiently extended and important to render the science well worthy the attentive consideration of the medical student.

I shall now turn from that part of my subject, not, however, because those aspects have been by any means exhausted, or because I have said all that *could* be said in favour of Botany when regarded from that point of view, but because I should ill befit my office if I did not call your attention to other considerations. The science of Botany has bearings far more extensive and far more important than the merely medical, whether we regard the vegetable kingdom as a whole, in its vital relations to the entire animal creation, and to Man in particular, or whether we view the simple cell which is at the foundation of every organised body, and by its aid as a stepping stone arrive inductively at broad views of vegetable, animal, and human physiology. The great domain of Nature may be conveniently divided into three kingdoms—the animal, the vegetable, and the mineral; and Botany in its widest and most comprehensive sense may be considered as embracing every kind of inquiry which can be made into all the varied phenomena of that kingdom which occupies the important and interesting intermediate position between the other two. Not only does it busy itself with the description of the infinite variety in the forms of vegetable organs, modified as they are by every condition of soil and climate, but the relative importance of each organ, its functions, and its uses to the well-being of the entire organism must be considered. These lead to that appreciation of natural affinities which is essential to the formation of a philosophical arrangement of the individuals composing the whole kingdom, both for purposes of reference and for the elucidation of botanical principles; while the study of the distribution of plants over the surface of the globe throws light upon the mutual relations existing between climate and vegetation; and the restoration of the plants of past and distant epochs assists in the comprehension of the affinities between those existing in our own day. I shall therefore touch upon each of these branches of Botanical Science—viz., Organography, Physiology, Taxonomy, Geography, and Palæontology, and endeavour to point out the scope and relations of each.

The great uses of a study which is in itself an accumulation of isolated facts, do not consist merely in such accumulation,

but that is, in fact, *the means* to the attainment of some higher and more important *end*, which can only be arrived at by some such tedious and laborious process. This end is Generalisation, or the deduction of broad principles from a comparison of results —a natural synthesis, by which Laws, as we call them, are discovered—which are, in fact, general expressions of the limits within which Creative Power thought fit to act. For the discovery of such general principles a high order of genius is necessary, in addition to an extensive and accurate acquaintance with facts, so that usually the observations of thousands furnish material for the generalisation of one. Vegetable Organography may be therefore regarded as the alphabet of the science, which it is necessary to master before broad principles can be even understood and appreciated, much less discovered. It is to Botany what Anatomy is to medicine—the groundwork upon which all safe inquiry is to be conducted. The vast accumulation of facts in Vegetable Organography has resulted in the discovery of that important generalisation which is usually designated as the Law of Morphology—a law which, although it leads to views which on a superficial inspection appear strained and unphilosophical, is nevertheless a truth whose fundamental simplicity and harmonious expression render it well worthy of attentive study and dispassionate examination—a law which reduces variety to unity, and expands uniformity into infinite complexity—the key, by means of which every variation of form, however remarkable—every deviation from type, however wide—every abnormality, however apparently capricious, may be referred to a common and well known elementary standard, by contrast with which its deviation may be measured and its abnormality explained. This great fact, the simplicity of which is proportionate to its importance, did not escape the discernment of the great Swedish Botanist, and Linnæus first gave, in his Prolepsis Plantarum,* indications that he regarded the leaf as the type of all the other parts. But he had obtained but glimpses of this great generalisation, and it remained for a poet to foster it, and for one of the greatest of modern botanists to adopt it,

* Amœnitates Academicæ. Vol. VI., p. 324.

before it was generally recognised. Goethe's† doctrine was tinged with the transcendentalism of his nation, and was, in fact, the *poem* of Morphology; De Candolle‡ dressed it in sober prose, divested it of its fantastic garb, and exhibited it in its simple grandeur, and it was forthwith accepted. Not, however, without opposition, as everything great is opposed; but *magna est veritas*, and no truth in Botany is now more firmly established than the doctrine of Morphology. Indeed so evident is its application that it is probable that only a misconception, arising from an unhappy choice of the term *metamorphosis*, stood in the way of its being at once embraced. The floral whorls are *not* metamorphosed leaves—they are physiologically totally different from leaves—they never were, at any period, leaves—and they cannot, therefore, be said to be metamorphosed leaves; but they are all formed upon the pattern and type of the leaf—they are, in other words, homologous with leaves; and if their special function be lost, they tend to a closer resemblance to their original type. Another term, no less unfortunate, is *Abortion*. There is no such thing as abortion in Nature, and what is thoughtlessly so designated is in reality the very opposite. *Modification* or *adaptation* is the proper term, for while abortion consists in a failure to arrive at the degree of perfection aimed at, Modification, which is what we everywhere meet with, is a special Adaptation, made by express design, to meet particular cases.

When this great principle of Homology is once accepted, what a view does it afford us of the Unity of the vegetable kingdom, since all the diverse and fantastic forms which give a feature to the vegetation of the globe are referable to one common standard. The complex ovaries, the delicate stamens, the gorgeous blossoms of the Magnolia and of the Rose, the insectiform flowers of the Orchideæ, the papilionaceous Leguminosæ, the feathery pappus of the Compositæ, and the helmet-like sepals of the Aconite—all these, no less than the capacious pitchers of Nepenthes and Sarracenia, the spreading fans of the Talipot and the Sabal, the phyllodia of the Acacias, and

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† Versuch die Metamorphose der Pflanzen zu Erklären. Gotha, 1790.
‡ Organographie Vegetale. Paris, 1827.

the twining tendril of the pea-like plants, are all modifications of a definite organ, consisting of a vascular petiole and a cellular lamina. On the other hand, what an impression does it give us of the illimitable fertility of design, and the supreme wisdom of the Divine Artificer who has so varied the pattern of the simple leaf, that not only an endless series of forms has resulted in the organs of plants, which at the same time delight the sense by the charms of variety, and employ the intellect in the search for uniformity, but has so adapted each modification to the purpose it has to fulfil, and to the peculiar conditions under which it exists, that the study of these mutual relations becomes an intellectual banquet, constantly renewed, and never surfeiting.

But it is probable that this law of Morphology may be safely carried yet further, and the investigations of Dr. M'Cosh seem to indicate that not only are the appendages of the plant modifications of the primary type, but that the whole plant is, in fact, built up upon a plan which may be examined in miniature in an individual leaf of it.* The correspondences which he has illustrated between the tree and the leaf relate to the presence or absence of the petiole, implying a corresponding developement of the stem—the disposition of branches of the tree, and the analogous distribution of veins of the leaf—the agreement of their angles of divergence, as well as their curves of arrangement; so that the varied physiognomy of the whole tree in a normal condition of growth is distinctly figured by each of the leaves, thus tending to prove that the leaf is the archetype of the entire plant, no less than of its individual organs. Should further investigations confirm the hypothesis of Professor M'Cosh, it will establish a principle of unity throughout the whole vegetable kingdom which analogy would lead us to believe as very probably existing, and which should not be confined to the vegetable world, inasmuch as the homologies already known to exist in the animal kingdom give promise of a similar generalisation in that department of Nature.

In studying the organs of plants one can hardly fail to be

* Proceedings of Edin. Bot. Soc. July, 1851. Reports of the British Association, 1854, p. 100.

struck by certain constant qualities which they exhibit, and which place their harmonious relations in a clearer light. The qualities to which I particularly refer are those of numerical relation, spiral form, and harmonious colouring. The constancy of particular numbers in particular classes of plants—the arrangement of fives in Dicotyledons, of threes in Monocotyledons, and of fours in Acotyledonous plants—is a circumstance which cannot be regarded as accidental. But numerical agreements are best illustrated in connection with spiral form, inasmuch as it has been shown that the fractions which represent the divergence of nodes in the ordinary forms of spiral development have a mutual relation, not single only, but threefold. These considerations are worthy of profound attention, and the universality of these numerical relations in the appendages of the plant, taken in connection with what has just been said concerning the unity of plan in the whole tree, renders it probable that some such numerical harmonies are at the foundation of those beauties of form which plants universally exhibit, and which are universally appreciated, and that a certain mathematical relation, in fact, exists throughout the whole vegetable kingdom, which, although its laws cannot be immediately studied, yet unerringly influences our sentiments of admiration, in the same manner that Mr. Hay has demonstrated the application of mathematical principles to be the basis of the ideal beauty in the human figure.

The law of spiral development is itself sufficiently remarkable to make such a generalisation probable. Its universality does not appear to me to be dwelt upon as its importance deserves.* The existence of a spiral impulse, if I may so designate it, is visible in the monarch of the forest, no less than in the simple cell. Aged trunks exhibit a spiral twist in their gnarled bark, and the same may be observed in old branches; scandent plants twine spirally round their supports; the law of alternation, (which is the expression of the spiral impulse,)

* I am aware that a considerable authority, Dr. J. M. Schleiden, is disposed to attach very little weight either to the spiral development or the numerical relations of parts in a plant. Such circumstances, which cannot be reduced to rigid scientific rules, are apt to strike differently constituted minds in a very different manner. The Jena Professor, however, it will be remembered, is sufficiently tenacious of a theory which he has once adopted, although it may want the support of analogy.

obtains almost universally in the growth of axial appendages; spires regulate the position of the floral whorls, no less than that of the true leaves, reaching a typical perfection in the scales of coniferous trees; the fundamental distinction between monocotyledons and dicotyledons consists but in a modification of the spiral in germinating seeds;* spiral embryos distinguish a division of Crucifers; spiral or phytozoary filaments play an important part in most, if not all, of the Cryptogamic divisions of plants; a spiral fibre keeps open the vessels of the medullary sheath; a similar spiral fibre is coiled within certain cells; spiral movements are visible throughout entire plants, constituting what is termed Gyration in Charads; and lastly, similar spiral movements take place within the limits of a simple membranous cell in many of the higher Phanerogams.

This universality of the spiral would seem to indicate forces acting in the vegetable kingdom with which, or with the modes of action of which, we are yet unacquainted, but which are well deserving of attention and research. Whatever they are, it may with probability be supposed that the same influence which acts upon the contents of the simple cell induces also the spiral arrangements of the more complex organs, as well as of the entire organism.

It may be remarked that analogous forces are not wanting in animal structures. The shells of Mollusca, whe therturbinate or discoidal, all exhibit evidence of a spiral formation, more or less distinct, of the kind called Logarithmic, and which has been examined with great acumen by Professors Moseley and Goodsir.

It is in the highest degree dangerous to call in question any apparent defect of adjustment in the works of Nature. So often have such assumed imperfections been proved to be nothing more than the fruit of deficient observation and hasty judgment, that one would suppose that philosophers would by this time have learnt the untenable ground which they occupied when urging such objections. But scarce any one, however eminent, has been free from this fault in some degree; and although the anatomist and physiologist can hardly be

* Cf. Lindley's Introduction to Botany, Vol. II., p. 67. London, 1848.

conceived to be in danger of falling into it to any great extent as heretofore, still there are aspects of Nature which engage attention, and whose relations are not apparent without special study. A rising doubt concerning any special adjustment not at once obvious should be sufficient to set the philosophical mind musing, with the persuasion that patient investigation will unfold relations and harmonies whose effects are visible to all, while their *rationale* is only disclosed to the candid inquirer. Thus it is with regard to the colours of flowers. The general aspect of the vegetable creation is proverbially pleasing, but still persons of high taste and conversant with the principles of æsthetics, have thrown out doubts whether there be in them any relation between form and colour. Dr. Dickie, of Belfast, has, however, lately pointed out as the result of widely extended observations, that such a relation *does* exist, both as regards the uniform colouring of regular flowers and the special distribution of colour in irregular corollas; and further, that a distinct and easily recognisable complementary harmony characterises the tints of flowers in general. The general conclusion which he derives from his observations is expressed as follows:—"That simplicity of figure corresponds with simpler contrast of colour in the monocotyledons, while greater complexity of colour and greater complexity of structure are in direct relation in dicotyledons."* But it is in fact this very perfection and balance of adjustment which renders us blind to it. Had the laws of harmony been violated in the colouring of flowers, the intuitive taste would have been offended, and the discord at once detected; but but where no discord exists, no jarring is perceived. The laws of the Beautiful are not agreed upon, but the educated eye, no less than the educated ear, assents to harmony however produced; and since it can be shown that the colours not only of the flower, strictly so called, but of the other chromatic parts of the plant, are complementary, so also they cannot be otherwise than harmonious.

* Typical Forms and Special Ends in Creation, by Profs. McCosh and Dickie, p. 153. Edin., 1857. In order to arrive at these results of Dr. Dickie's observations, I was led to procure this excellent work, and was gratified to remark how I had unknowingly regarded some of the subjects referred to in the present lecture from the same point of view as the learned authors.

If the study of the structure of vegetable organs be of so interesting a nature, from its unfoldng relations the most unlooked for, and adaptations the most exquisite, a consideration of the plant in action and in full performance of its physiological functions is no less important, as illustrating the remarkable position occupied by vegetables in the organic scale, and the entire dependence upon them of animals, not only for subsistence, but also for the very air they breathe. The plant stands between the herbivorous animal and the inorganic elements which compose the crust of the earth, and by a vital or chemico-vital power entirely peculiar to itself, converts the latter into a pabulum adapted to the former. No animal can exist unless it receives as food matter in a certain state of combination, which we designate *organised;* and the plant, with which such a necessity does not exist, is constantly preparing for the animal vast stores of nutriment by taking up the simple elements of which the earth's crust is composed, and combining them into ternary and quarternary compounds of the most complex description. The vegetable world is a vast laboratory, in which inorganic matter is taken up, elaborated, and fixed, no longer dead, mineral, and innutritious, but part of a living tissue, performing vital actions so long as the organism exists, and affording a pabulum fitted for animals, by means of which the highest functions of the perceptive creature may be adequately performed. Viewed in this aspect, the vegetable creation receives an importance inferior to no department of Nature. A plant may be regarded on the one hand as a living organism whose whole existence is one round of antagonism to animal life: whatever is essential to the well-being and functions of an animal, we may be almost certain to be opposed to the requirements of a plant—those elements which are fatal to the one, are the very essence of existence to the other. But, on the other hand, this very antagonism is made to subserve to the most perfectly balanced harmony between the two, and to result in their mutual and inseparable advantage. They are therefore rather to be regarded as dual powers, mutually assisting one another, than as antagonistic; the one totally and entirely dependent upon the other—a disturbance in the balance

of the functions of the one inevitably reacting, and causing a failure in the powers of the other. But while their mutual dependence is thus illustrated, the subserviency of plants to the higher functions of animal life becomes apparent, since it is they who originate organic matter, and who reorganise the elements loosened from their combination by the decay of animal bodies. A careful study of Vegetable Physiology, especially when added to the examination of the lower forms of Animal life, is therefore the best school in which to learn the true relations of living organisms, and the means by which we may hope to attain a deeper insight into the nature of vital force. It is in vegetables that this vital power first makes its appearance, and it is through them that it is communicated to earthy materials. A consideration of the textures of plants, taken in this relation, cannot fail to surprise the inquirer from the apparent simplicity of the organisation which performs these important changes—changes which the chemist in his laboratory, aided by all the appliances of art, and the accumulated knowledge and experience of the thousands of years which have elapsed since the birth of that ancient science, with few exceptions, vainly attempts to imitate. The nature of this simplicity cannot be better expressed than it is in the opening passage of Lindley's "Vegetable Kingdom:" — "Organic vesicles usually extending into tubes of various kinds exclusively constitute vegetation, but the simplicity of nature is attended by very complex details of arrangement, as is shown in trees, whose framework is knit together by countless myriads of such vesicles and tubes, entangled with *an astonishing intricacy of simple arrangement*" Vesicles and tubes are indeed the apparatus by which the organic alchemy is effected, but the essential organ which performs the wonder may be regarded as the simple cell, consisting of a membrane inclosing a minute quantity of a certain plastic substance. To this protoplasm the membrane probably plays only a subordinate part, its chief importance being, according to Mr. Thwaites, "to locate, protect, or isolate the matter it contains," Here, then, we have arrived at the simplest expression of organising power which our senses have yet sufficed to reach; and it is by a

careful study of the contents of the vegetable cell that any advance is to be made in the comprehension of the phenomena of life.

Much has been learnt from such an attentive examination, and much light has been thrown upon the physiology of the more complex organs of the higher animals by a consideration of vital phenomena as exhibited by the most remote divisions of the animal and vegetable kingdoms. The more we can simplify these phenomena, the more we can reduce the complexity of the organs exhibiting them, the more probability is there of our arriving at the laws which govern them and the modes in which they act. The earliest possible life, then—that exhibited by the lowest dawning forms, becomes the most valuable to this end, and we find in the independent cells of Protococcus and Torula, organs in which the utmost degree of simplicity is attained compatible with the performance of vital functions. Still the complex operations of these functions baffles us; nutrition is carried on, the cell as an individual lives and dies, but not before it has provided for a successor; and reproduction is no less perfect after its kind in the simple cell than in the more complex organs of higher organisms. Two cells may be undistinguishable from one another by the highest powers of the microscope, or by the nicest chemical tests, and yet possess functions essentially distinct; which distinction could not, in the nature of things, exist without a difference of constitution. There *are*, therefore, existing differences in apparently similar cells, which imply forces whose nature or whose minuteness we cannot appreciate; but this does not necessitate the existence of forces altogether unknown to us. The effects of light, heat, electricity, and chemical combination are to a certain extent known, but is their nature appreciated, and are their mutual relations fully understood? Light and heat we know to have most important influences upon vegetation, but we cannot yet measure their value and extent; chemical differences are obvious in the mass, may they not exert important influence upon the component parts? while electrical currents can only be inferred or conjectured from the presence of regular crystals in the cell;

but where there is chemical combination, must there not also be electrical action? and the regular movements so frequently observed within cells would seem to point to this as their determining cause. Such papers as that of Mr. Thwaites on Cell Formation,* and the speculations of Dr. Carpenter on the mutual relations of vital and physical forces† awaken deep reflections, and almost inspire a hope that glimpses at least towards the comprehension of vital phenomena are not so far beyond the reach of human analysis as might at first sight be supposed.

The application of Vegetable Anatomy and Physiology to the Classification of plants is a subject of high interest and importance. The necessity of some such classification is apparent when the vast mass of materials is considered, both for the purpose of rendering available the discoveries already made, and also for the comprehension of the relations of constantly increasing novelties. A careful study of natural affinities is necessary to this end, undoubtedly useful as it is, and which, in a restricted sense, may be considered one of the chief aims of botanical investigation. Although, however, it should not be regarded as the grand and ultimate aim, the labours of systematic botanists are not to be despised. They to whom we are most indebted for a successful generalisation in this department, and who have been most happy in the arrangement of the vegetable kingdom in a natural and truthful manner, have been Botanists who possessed the widest acquaintance with the descriptive and physiological parts of the science; for without these, approximations cannot be arrived at, and nothing but fallacious and perishable results can be obtained. The steps by which botanists have attained the present degree of perfection are interesting and instructive, and while they show that the path is open before us to a correct system, they also indicate that perfection in this department cannot be arrived at, until we can take cognizance of a vast number of plants which, "born to blush unseen," have hitherto eluded the energetic researches of the exploring traveller.

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* Ann. Nat. Hist., Vol. XVIII.
† Phil. Trans., 1850.

To the ancients little arrangement was known beyond the simple one into trees, shrubs, and herbs, and this probably amply sufficed for the requirements of their limited knowledge of vegetables, which does not appear to have embraced more than five or six hundred plants. But in modern times the rapid increase of our acquaintance with newly discovered materials has given rise to systems ever changing, though not always new. The old herbalists of the sixteenth century, who studied plants solely as the depositaries of elixirs, decoctions, and electuaries, which were supposed to soothe all mental as well as bodily ailments, adopted divisions no less artificial, and their botanical descriptions, which contained as much of fable as of truth, referred to plants as esculent or medicinal, bulbous or grassy. It was Conrad Gesner, and soon after him Andreas Cæsalpinus, who first conceived the idea of taking some important organ as a basis for classification; and they selected the fructification. The work of the latter, published in 1583, describes 1,520 plants, which were all that were then known. A century later, Rivinus and Tournefort classified nearly 8,000 species of plants, founding their classes upon the corolla, and their orders upon the fruit. To this there was the manifest objection, that inasmuch as flower and fruit are seldom seen together, it was necessary to wait a month after discovering the class before the order could be ascertained. In the History of Classification, our illustrious countryman, John Ray, holds an honourable position; about the close of the seventeenth century, and simultaneously with the system of Tournefort, appeared his Historia Plantarum—a work still in use as a book of reference, wherein are described on principles which near a century later formed the foundation of the system of Jussieu, 8,625 plants, the limits of botanical knowledge in that day. Thirty years later, about 10,000 plants being known, the great Linnæus promulgated his admirable artificial method, which, with all its defects, (and well its author knew them,) has done vast service to botanical science, and remains a monument of his acumen and originality. The Linnæan system has been ungenerously decried by many who have failed to perceive its influence on the more natural and perfect methods of Jussieu

and De Candolle; but it should never be forgotten, in the first place, that the re-modeller of Natural History was well aware of the true principles upon which a natural classification would ultimately be founded, and in the second place, that the artificial system has materially assisted the introduction of the method of Jussieu, by its value as an index, by means of which temporary order and arrangement became a matter of the most perfect and complete facility, and thus accomplished the first great and difficult stride to higher things.

Simply, therefore, as a system for reference, the Linnæan method admirably answers the conditions proposed; but for a comprehensive and philosophical view of the vegetable kingdom, natural affinities must be elucidated, and the principle of unity discovered and illustrated. In order to place the difficulties of a natural classification in their proper light, let us suppose that 200,000 cards are each marked with a secret but complex sign in such a way that the whole number forms a series. Let us next imagine that the whole series be shaken into a vast heap, and mingled together in wild confusion; and further, that 192,000 of them be then abstracted at random, and concealed from view. If a person were now requested to examine the remaining 8,000 for the purpose of discovering the clue to that secret series with which the whole are marked, what difficulty would he find in the attempt; he would indeed scarcely be in a position to make an approximation to the truth, and unless possessed of extraordinary sagacity, would give up the attempt in despair. Such was the position of Botanical Science in Ray's time, when our excellent and pious countryman succeeded, in spite of these drawbacks, in reaching such an approximation. Let us now suppose that two or three more thousands of the concealed series are brought to light, thus increasing the number at command. The facilities for arriving at correct ideas of the whole are proportionately increased, but other difficulties at the same time arise. The number under examination is so considerable, that although it bears but a small proportion to the whole, yet, in the absence of the proper clue, it becomes unwieldy, and without some artificial and temporary method of arrangement the inquirer

would be lost in the very complexity and abundance of his materials. Linnæus met that difficulty, which would have increased every day but for his simple and admirable artificial system, which, if it were useful then, became yet doubly so before the clue was recognised. Regarded in this light, the services of Linnæus exhibit a value unmatched by those of any other naturalist; and even apart from the vast benefits to science from his dual system of nomenclature, his botanical terminology, and his revision of species both of plants and animals, his artificial system has paved the way for, and considerably hastened the introduction of, a natural system, while at the same time it has tended to advance the science by popularising it. And be it remembered that Linnæaus justly estimated the relation it bore to the natural system, the "primum et ultimum desideratum," as he termed it; while no one knew better than he that "the formation of a natural system must result from a close attention, not to one or two, but to *all* the parts of plants." These are his own words. But the illustrious Swede was a man of a thousand—one of that handful of men whose appearance in all ages of the world has marked an era in philosophy—one of those human landmarks whose personal history is the History of Science. It was no fault of his, if his successors, from a blind adherence to their master, mistook the shadow for the substance, and in their anxiety for his honour resisted the improvements to whieh he had hopefully looked forward.

It was Jussieu who, in 1774, still having less than 20,000 numbers of the series at his disposal, by deep study and patient research, aided by profound sagacity, indicated the principles on which a natural classification was finally to be established, and thereby showed that Ray and Linnæus had both foreseen them. He formed a system which was modified and improved by De Candolle and his successors, aided by the vastly and rapidly increasing knowledge of species. All botanists, however, were not so discriminating as these chiefs of the science, and the new clue was not immediately recognised, although placed in a prominent position. Like all truths, it met with resistance at first, and it remained for

the authority of Robert Brown* to establish it in this country.

The objectors to the natural system—and there yet remain some, on the ground of its incompleteness and imperfection—must bear in mind that of the 200,000 which I have supposed to constitute the entire series, only about 100,000 are yet known and described, and of these many but imperfectly, and therefore uselessly in a practical point of view.† The remainder lie scattered abroad in the rich but unexplored regions of America, Africa, India, China, and Australia, as well as entombed in the bowels of the earth—from the Lepidodendron of the lower old red sandstone to the Protolarix of the upper tertiary. All these must be compared and understood before a perfection of system can be reached, and the absolute unity of the whole plan fully demonstrated.

The limits of a lecture will not permit of more than an allusion to the two remaining branches of botanical inquiry—viz., the geographical distribution of plants and the geology of Botany. These two subjects bear intimately upon one another, and it will be convenient to refer to them in the same connection. The first thing which strikes the student of botanical geography is the universality of the vegetable creation. While the tropical heat of the globe is most productive of the rank and luxurious vegetation so picturesquely described in the works of Humboldt and Waterton—unless, indeed, as in the African deserts, totally unaccompanied by moisture—there is scarcely any spot of land in the frigid polar regions where some member of the kingdom does not exist. It may be only a humble moss, or a crustaceous lichen, whose tough, coriaceous epidermal covering resists the utmost degree of cold, and with no soil except that which it makes for itself on the adamantine surface of the bare granite rock, holds its ground, and proclaims the plastic hand of Nature, where all else is rude, primitive, and chaotic. Nay, according to Humboldt,‡ the simple living cells of Discerea (Protococcus) Nivalis "exist in the polar snow as well as in that of high mountains." Between these two

* While these sheets were in the press, this venerable philosopher, "Botanicorum facilè princeps," has passed away from the scene of his unwearied labours.

† Meyen's Geography of plants, p. 4., Ray. Soc.

‡ Cosmos, Vol. I., p. 353. Bohn's Edition.

extremes of conditions what infinite diversity of forms give a distinctive physiognomy to every zone, from the vast foliar expansions of the equinoctial plantains to the needle-shaped leaves of the pine-trees of the north. But it is not merely the zonal gradations of heat which determine this diversity, but the geognostic nature of the soil plays an important part in producing conditions favourable or unfavourable to particular classes of vegetation. Again, the unevenness of the surface of the earth, the result of geological changes of past epochs, modifies in all parts of the globe the nature of its flora; and, just as the same cause has disturbed the uniformity of the strata, and by their dip brought all to the surface, so as to be readily inspected by man, so the elevation of mountain ranges within the tropics, as well as in more temperate regions, has caused the existence of floras which in the space of a few miles epitomise the productions of vast latitudinal areas, and in any given country bring before the attention of the observer diversities which are only more extensively illustrated in the transit from the equator to the poles. The original distribution of plants is by the same influences so modified that it becomes difficult for the botanist, even with the aid of the physical geographer, to determine whether primary specific centres existed which have since been broken up by geological convulsions, and by a total alteration of the conformation of the land, have become scarcely distinguishable in the present day; or whether the same species of plants in the beginning were generally distributed over different and far distant localities, where similar conditions of temperature and soil permitted them equally to grow and flourish. The former theory is a favourite with geologists, and De Candolle, in his Essay on Botanical Geography, admits that though a certain degree of analogy, aspect, and even structure, might very possibly be discoverable between the plants of two distant localities presenting the same circumstances of temperature, altitude, soil, and humidity, nevertheless the *species* would in general be different.*

The discovery of vast accumulations of vegetable remains in a fossil state gives rise to considerations bearing intimately upon

* See Lyell's Principles of Geology, Vol. III., p. 4.

botanical geography. How is it that among these remains we find structures in high temperate latitudes which in our own day are only developed under the influence of a tropical sun? In considering this question we must bear in mind the general nature of those remains. In the beds of coal which exercise such a vast influence upon modern civilisation, and which extend up to a high degree of latitude, "the flora," says Lyell, "consisted almost exclusively of large vascular cryptogamic plants,"—Equisetaceæ upwards of ten feet high, and from five to six feet in diameter; tree-ferns, forty to fifty feet high, and arborescent Lycopodiaceæ from sixty to seventy feet high. This is a scale of vegetation not reached in equinoctial temperatures now, and presupposes an amount of heat and humidity in former ages of the world which we can hardly appreciate in the present day. Such degrees of heat, however, are reconcileable with other phænomena, and the vast impregnation of the humid atmosphere with carbonic acid is indicated by the prevalence of limestones at a contemporary period.* If, however, these giant forms of cryptogamic vegetation grew upon the spots where they are entombed, we cannot imagine them to have had an amount of light such as in lower latitudes accompanies intense heat, inasmuch as light being derived solely from the sun, must in the most favourable circumstances vary with latitude; whereas the heat of the earth was something inherent in itself, or at all events would vary with the disposition of the land. It becomes probable then that the rank luxuriance of the vegetation in the carboniferous era was due to the peculiar physical conditions of the earth at that period, when the waters under the heaven were gathered together into one place, and the dry land first appeared; but *before* the lights in the firmament of the heaven had so penetrated through the dense and humid atmosphere of waters which were above the firmament as to divide the light from the darkness, and to be for signs and for seasons, and for days and for years.† In such a period of the earth's physical history the lately formed dry land would have been subject to constant volcanic paroxysms, which might be supposed to have been accompanied by the disengagement of carbonic acid in quantities which would be fatal to animal life, but which

* Lyell, Princ., Vol. III., p. 301.
† Gen. i., 9, 14, 15.

would result in a degree of luxuriance of vegetation such as now, on a smaller scale, is illustrated in the remarkable volcanic district of Auvergne.

Dr. Carpenter, in a paper before referred to, suggests that "in making use of the stores of coal which have been prepared for his wants by the luxuriant flora of past ages, man is not only restoring to the atmosphere the carbonic acid, the water, and the ammonia which it must have contained in the carboniferous period, but is artificially reproducing the light and heat which were then expended in the operations of vegetable growth." Nothing, indeed, is lost in the economy of Nature—materials the most fleeting and impalpable once generated, we cannot conceive to be annihilated. Changed they may be by new combinations, fixed into solidity, set free and restored by decomposition into their primitive tenuity and subtlety—but lost, never. Dr. Carpenter further observes, "that the relative proportion of the light and heat thus restored should be the same as that which they originally bore to each other is by no means necessary; since each (according to Professor Grove's views) is convertible into the other;" but without thus having recourse to any operations which may complicate these views, it will readily appear, from the view of the case just now propounded, that the amount of *light* which these carboniferous floras received bore but a small proportion to the *heat* to the action of which their production was due.

If, however, it should really be the fact that the gas-illumination of our streets and our dwellings, our domestic fireside, our vast manufactures, our appliances for the production of force, by which time is reduced, space abridged, and labour economised—if all these should be but the fruition of the accumulated physical forces and agents, as well as changes and combinations, which have occupied the vast interval during which the earth was preparing—no less than the stores of solid material in the shape of iron, of metals, of stone, on which these impalpable and immaterial forces were destined to act when the human era arrived—to what wonder-inspiring thought does it not lead us! And what a lofty idea does it afford us of the power, the knowledge, and the benevolence of the Creative Intelligence, who could with a comprehensive glance through the dim vista of Time, even before the

foundations of the earth were laid, foresee the mutations, the instabilities, and changes—the decay, death, and extinction, which should reign for ages unchecked, and should so order and arrange them all, that the result should be, not chaos and confusion, which to a finite mind would appear inevitable, but harmony and unity, adaptation and subserviency to the abundant and ever increasing requirements of rational man. Man, indeed, is the last actor upon the cosmical scene—a being endowed on the one hand with instincts of such an order as teach him to reap the advantages of these ages of preparation, and on the other with Intelligence which inspires him with the desire to aim at the discovery of the modes by which these wonders have been achieved. Worthy indeed are such inquiries of the loftiest intellects, and to such may be applied the words of one who was himself a divinely-taught Naturalist, and the wisest of mankind—

> "IT IS THE GLORY OF GOD TO CONCEAL A THING;
> "BUT THE HONOUR OF KINGS IS TO *SEARCH OUT* A MATTER."
>
> Proverbs xxv., 2.

THE END.

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